AMENDMENTS TO THE DRAWINGS:

The attached sheets of drawings include changes to Figures 1, 2, 4, 12, 14, 20, 24, 25, 27, 29, 31, 40, 41, 47 and 53. These sheets, which include Figures 1-54, replace the original sheets including Figures 1-54.

Attachment: forty-one (41) replacement sheets

REMARKS

In the February 6, 2008 Office Action, the drawings, title and claims 1-13, 24-26 and 29 were objected to, and claims 1-4, 10, 14-18, 24 and 29-32 were rejected in view of prior art. On the other hand, claims 5-9, 11-13, 19-23, 25-28, 33 and 34 were indicated as containing allowable subject matter. Applicant wishes to thank the Examiner for this indication of allowable subject matter and the thorough examination of this application. No other objections or rejections were made in the Office Action.

Status of Claims and Amendments

In response to the February 6, 2008 Office Action, Applicant has amended the specification, drawings and claims 1-19 as indicated above. Also, Applicant has cancelled claims 20-34. Thus, claims 1-19 are now pending, with claims 1 and 10 being the only independent claims. Reexamination and reconsideration of the pending claims are respectfully requested in view of above amendments and the following comments.

Drawings

In paragraphs 2 and 3 of the Office Action, the drawings were objected to as failing to comply with 37 CFR §1.83(a). In response, Applicant has filed herewith forty-one (41) sheets of replacement drawings with changes to Figures 1, 2, 4, 12, 14, 20, 24, 25, 27, 29, 31, 40, 41, 47 and 53.

In Figure 1, one occurrence of the duplicated labels "GU1, GU2 and GU3" have been replaced with the missing labels "GW1, GW2 and GW3" as suggested in the Office Action. Accordingly, withdrawal of the objection to this Figure is respectfully requested.

In the active filter power module of Fig. 2, reference numerals have been added as follows: 100 designates a noise filter, 101 designates a diode bridge, 102 designates an IGBT, 103 designates a load, 104 designates a multiplier, 105 designates an Input current negative feedback circuit, 106 designates over temperature protection, 107 designates a short protection, 108 designates an output voltage Negative Feedback circuit, 109 designates over voltage protection, 110 designates a comparator, 111 designates an oscillator, 112 designates a buffer, 113 designates a control source voltage reduction protection, 114 designates an error output S1 and S2 designate switches, R1-R4 designate resistors, C1-C4 designate capacitors and L designates a reactor. Figure 2 has also been enlarged and redrawn for clarity. Accordingly, withdrawal of the objection to Figure 2 is respectfully requested.

With respect to the objection to missing labels in Figures 4, 12, 14, 20, 24, 25, 27, 29, 31, 40, 41, 47 and 53, these Figures have been amended as follows: Figure 4 has been enlarged, and broken line boxes have been added, which merely outline portions of the substrate. These broken line boxes do not have reference numerals added as explained below. Figure 12 has been enlarged and redrawn for clarity. Figure 14 has been enlarged and redrawn for clarity. Also, the shading in Figure 14 has been corrected. Figure 20 has been enlarged and redrawn for clarity. Also, one broken line box has been added to Figure 20, which merely outlines a portion of the substrate. Figure 24 has been enlarged and redrawn for clarity. Also, the shading in Figure 24 has been corrected. Finally, broken line boxes have been added to Figure 24, which merely outline portions of the substrate. Figure 25 has been enlarged and redrawn for clarity. Also, the shading in Figure 25 has been corrected. One broken line box was removed from Figure 25 since the box was not located on the substrate. Figure 27 has been enlarged and redrawn for clarity. Also, the shading in Figure 27 has been corrected. Figure 29 has been enlarged and redrawn for clarity. Also, the shading in Figure 29 has been corrected. Figure 31 has been enlarged and redrawn for clarity. Also, the shading in Figure 31 has been corrected. Finally, broken line boxes have been added to Figure 31, which merely outline portions of the substrate. Figure 40 has been enlarged and redrawn for clarity. Also, broken line boxes have been added to Figure 41, which merely outline portions of the substrate. Figure 41 has been enlarged and redrawn for clarity. Finally, broken line boxes have been added to Figure 41, which merely outline portions of the substrate. Figure 47 has been enlarged and redrawn for clarity. Also, one broken line box has been added to Figure 47, which merely outlines a portion of the substrate. Figure 53 has been enlarged and redrawn for clarity. Also, one broken line box has been added to Figure 53, which merely outlines a portion of the substrate. No new matter has been added by these changes to the drawings.

The objection to Figures 4, 12, 14, 20, 24, 25, 27, 29, 31, 40, 41, 47 and 53 is respectfully traversed in view of the above changes and the following comments. The boxes shown in Figs.4-12, 15-20, 23-31, 33, 34, 36-40, 43-47, 49-54 indicate areas on a substrate on which a plurality of types of surface mounted devices can be mounted. The specification of the instant U.S. patent application, at the bottom column of Table 3 on page 43, for example, states "The proposed three phase - three phase power module can be modified by changing only the type of a surface mounted power device...", and a plurality of examples of modified

power modules are described from the second column of below Table 3 on page 43 through line 4 of page 47 (Please also refer to Figs. 4-7 and 32-35). From these descriptions and Figures, it is readily apparent to a person of ordinary skill in the art that boxes in the Figures indicate areas on a substrate on which any of plurality of types of surface mounted power devices (for example IGBT, diode, smoothing condenser, etc) can be mounted. Since only positively claimed elements must be identified in the drawings, the areas outlined by the boxes are not required to be identified by reference numerals.

A surface mounted device may not be mounted on some of the areas, for example, a surface mounted power device is not provided on the box below a smoothing condenser in Fig. 5 and two boxes on the side of inverter 20. In other words, it is readily apparent to a person of ordinary skill in the art that the boxes without circuit characters indicate areas on which surface mounted power devices can be mounted, but are not illustrated as being mounted. Since no box is indicated for a smoothing condenser in Figs. 27, 29, 31, and diode 17 in Figs. 12, 14, 20, 24, 40, 41, 47, and 53, the correctly amended figures attached include such boxes, as explained above. Further, since Fig. 25 includes an unnecessary box (a box on the right side of condenser 7), Applicant has deleted the box, as explained above.

The reactor now set forth in claim 7 is shown in Figure 28. The reactor now set forth in claim 8 is shown in Figure 29. Applicant believes that the drawings now comply with 37 CFR §1.83(a). Applicant respectfully requests withdrawal of the objections.

Title

In paragraph 4 of the Office Action, the title was objected to, and a new title was required that is clearly indicative of the invention to which the claims are directed. In response, Applicant has amended the title to read "AC/AC Power Converter and Substrate". Applicant believes the new title is clearly indicative of the invention to which the claims are directed. Accordingly, withdrawal of this objection is respectfully requested.

Claim Objections

In paragraph 5 of the Office Action, claims 1-13, 24-26 and 29 are objected to for informalities. In response, Applicant has cancelled claims 24-26 and 29, and deleted the objectionable language "formed required wirings". The reactor now set forth in claim 7 is shown in Figure 28, and antecedent basis is found in the original specification at page 42. The reactor now set forth in claim 8 is shown in Figure 29, and antecedent basis is found in

the original specification at page 45. Accordingly, withdrawal of these objections is respectfully requested.

Specification

In the specification, the title has been changed, as mentioned above. Also, the word "condenser" has been changed to –capacitor—to make the terminology consistent with the U.S. The reference numerals added to Figure 2 have been added to the specification.

Rejections - 35 U.S.C. § 102

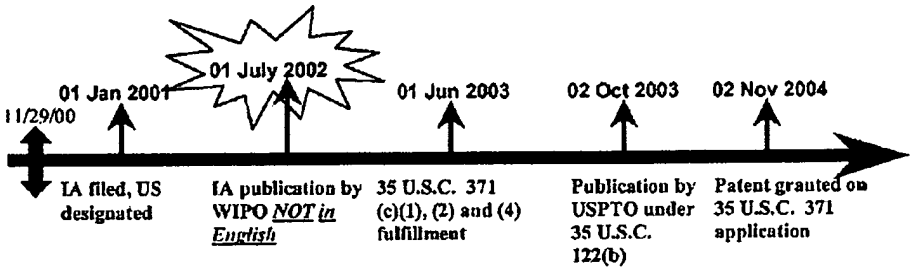
In paragraph 7 of the Office Action, claims 1, 2, 14-16 and 30 stand rejected under 35 U.S.C. §102(b) as being anticipated by U.S. Patent Application Publication No. 2007/0139978 (Maeda et al.). In response, Applicant has amended claims 1-19 to clarify the subject matter of these claims. These claims have not been amended based on the prior art rejection because the rejection is improper, as explained below.

Applicant respectfully asserts that the ***Maeda et al. publication does not qualify as prior art*** of the present application because the Maeda et al. publication is based on the national stage of an international application filed after November 29, 2000 which was published as WO/2005/060082 in Japanese under PCT Article 21(2). MPEP 706.02(f)(1)II Example 5 (page 700-34 of MPEP) as reproduced below clearly states "[a]ll references, whether the WIPO publication, the U.S. patent application publication or the U.S. patent, of an international application (IA) that was filed on or after November 29, 2000 but was not published in English under PCT Article 21(2) have ***no 35 U.S.C. 102(e) prior art date at all***" (emphasis added). Accordingly, the Maeda et al. publication has ***no*** 35 U.S.C. §102(e) date, and thus, does not qualify as prior art of the present application. See MPEP 706.02(f)(1)II Example 5 as shown on the next page, and attached Exhibit A.

In other words, in this case, only WIPO publication WO/2005/060082, which was published on June 30, 2005, could possibly be applied as prior art. However, the instant application has an international filing date of July 30, 2003 (i.e., before WIPO publication WO/2005/060082), and thus, WIPO publication WO/2005/060082 does not qualify as prior art whatsoever of the instant application. Accordingly, withdrawal of this rejection is respectfully requested.

Example 5: References based on the national stage (35 U.S.C. 371) of an International Application filed on or after November 29, 2000 and which was not published in English under PCT Article 21(2).

All references, whether the WIPO publication, the U.S. patent application publication or the U.S. patent, of an international application (IA) that was filed on or after November 29, 2000 but was not published in English under PCT Article 21(2) have no 35 U.S.C. 102(e) prior art date at all. According to 35 U.S.C. 102(e), no benefit of the international filing date (nor any U.S. filing dates prior to the IA) is given for 35 U.S.C. 102(e) prior art purposes if the IA was published under PCT Article 21(2) in a language other than English, regardless of whether the international application entered the national stage. Such references may be applied under 35 U.S.C. 102(a) or (b) as of their publication dates, but never under 35 U.S.C. 102(e).



The 35 U.S.C. 102(e)(1) date for the IA Publication by WIPO is: None.
The 35 U.S.C. 102(e)(1) date for the Publication by USPTO is: None.
The 35 U.S.C. 102(e)(2) date for the Patent is: None.

The IA publication by WIPO can be applied under 35 U.S.C. 102(a) or (b) as of its publication date (01 July 2002).

Additional Priority/Benefit Claims:

If the IA properly claimed priority/benefit to any earlier-filed U.S. application (whether provisional or nonprovisional), there would still be no 35 U.S.C. 102(e) date for all the references.

If a later-filed U.S. nonprovisional (35 U.S.C. 111(a)) application claimed the benefit of the IA in the example above, the 35 U.S.C. 102(e) date of the patent or publication of the later-filed U.S. application would be the actual filing date of the later-filed U.S. application.

Rejections - 35 U.S.C. § 103

In paragraphs 9 and 10 of the Office Action, claims 3, 4, 10, 17, 18, 24, 29, 31 and 32 stand rejected under 35 U.S.C. §103(a) as being unpatentable over the Maeda et al. publication in combination with U.S. Patent Application Publication No. 2002/0034089 (Mori et al.) or Japanese Patent Publication No. 10-225138 (Suzuki). As explained above, the Maeda et al. publication does not qualify as prior art to the instant application. thus, any rejection based on this publication is improper. Accordingly, withdrawal of these rejections is respectfully requested.

Allowable Subject Matter

In paragraph 11 of the Office Action, claims 5-9, 11-13, 19-23, 25-28, 33 and 34 were indicated as containing allowable subject matter. Applicant wishes to thank the Examiner for this indication of allowable subject matter and the thorough examination of this application. In response, Applicant has not amended claims to place them in independent form because the rejections set forth in the Office Action are improper, as explained above.

Prior Art Citation

In the Office Action, additional prior art references were made of record. Applicant believes that these references do not render the claimed invention obvious.

* * *

In view of the foregoing amendment and comments, Applicant respectfully asserts that claims 1-19 are now in condition for allowance. Reexamination and reconsideration of the pending claims are respectfully requested.

Respectfully submitted,

/Patrick A. Hilsmier/
Patrick A. Hilsmier
Reg. No. 46,034

GLOBAL IP COUNSELORS, LLP
1233 Twentieth Street, NW, Suite 700
Washington, DC 20036
(202)-293-0444
Dated: June 30, 2008
S:\06-JUN08-YTY\DK-US055015 Amendment.doc

Specification

~~Power Module for~~ AC/AC Power ~~Conversion~~ Converter and Substrate

Field of the Invention

[0001] The present invention relates to a power module for AC/AC power conversion. More particularly, the present invention relates to a power module for converting an AC voltage to a desired AC voltage using a converter and an inverter.

Background Information

[0002] For long years, a power module with two switches or a power module with four switches was a device only which has been used excessively within the power conversion field. Main reasons for standardizing those power modules are for simplicity and for universal application. Such type of power modules are commercially supplied under various names such as an integrated gate bipolar transistor module "IGBT MOD", an intelligent module "ASIPM" for specific application, and a dual inline package intelligent power module "DIP-IPM". All the above example are developed to improve only conditions of load-side application. But, grid-side was always ignored because of lack of the reason for severe competition.

[0003] In recent years, EMC regulation and worldwide market economy have changed their conditions very rapidly. And, a new type of power module has introduced in the market.

[0004] First, a matrix module was introduced from Olaf Simon, et al, "Modern Solution for Industrial Matrix-Converter Applications", IEEE Transactions on Industrial Electronics pp/401-406, V61.49, No.2, April 2002 and Patrick W. Wheeler, et al, "Matrix converter: A Technology Review", IEEE Transactions on Industrial Electronics pp/276-288, V61.49, No.2, April 2002. As is illustrated in Fig. 1, this module intends AC-AC conversion in three phase.

[0005] Second, an active-filter intelligent power module "A/F IPM" was proposed from G Mjumdar, et al, "Intelligent power module applications", IEEJ Technical Report No.842, pp. 13-19, Jun 2001. As is illustrated in Fig. 2, "A/F IPM" intends power factor correction on grid-side for single phase application. In the active filter power module of Fig. 2, 100 designates a noise filter, 101 designates a diode bridge, 102 designates an IGBT, 103 designates a load, 104 designates a multiplier, 105 designates an Input current negative feedback circuit, 106 designates over temperature protection, 107 designates a short

protection, 108 designates an output voltage Negative Feedback circuit, 109 designates over voltage protection, 110 designates a comparator, 111 designates an oscillator, 112 designates a buffer, 113 designates a control source voltage reduction protection, 114 designates an error output S1 and S2 designate switches, R1-R4 designate resistors, C1-C4 designate capacitors and L designates a reactor.

Problems of prior power modules are as follows:

1) In general, due to the standard design, external circuits are required for a specific application such as power factor correction on grid-side;

2) The design should be changed according to each of application categories such as a power supply type (200V, 100V, 400V, .. , or the like) and a load type such as a motor for 200V, or a motor for 400V. This results in increase in model types. This means the increase in cost of final products.

3) The proposed matrix module has advantage in that realization of three phase-three phase system can serve all systems. But, it cannot be applied to single phase/three phase system. Because the application is restricted only to three phase/three phase system and three phase/single phase system.

4) "A/F IPM" cannot be applied for three phase-three phase conversion for the purpose of specific applications.

[0006] The present invention was made in view of the above problems.

[0007] It is an object of the present invention to provide a power module which can easily be dealt with various types of power modules.

Summary of the Invention

[0008] A power module for AC/AC power conversion of a first aspect is a power module in which multiple converter components constituting a multiple phase converter, multiple smoothing ~~condensers~~ capacitors, and multiple inverter components constituting a multiple phase inverter can be mounted on a substrate which has been formed necessary wirings,

[0009] the power module is arranged in that at least a part of converter components, at least a part of smoothing ~~condensers~~ capacitors, and at least a part of inverter components complying with required specification of the power module are mounted on the substrate, and that necessary jumper means are provided.

[0010] A power module for AC/AC power conversion of a second aspect employs a three phase converter as the multiple phase converter, determines the number of smoothing

~~condensers~~ capacitors to be 2, and employs a three phase inverter as the multiple phase inverter.

[0011] In a power module for AC/AC power conversion of a third aspect, the three phase converter comprises a pair of transistors serially connected to one another for each phase, and diodes each connected in parallel to each transistor, at least a part of diodes and/or at least a part of transistors and diodes complying with the required specification of the power module are mounted on the substrate, and necessary jumper means are provided. In a power module for AC/AC power conversion of a fourth aspect, the three phase converter comprises a pair of transistors serially connected to one another for each phase, and reflux diodes each connected in parallel to each of the transistors, at least a part of diodes and/or at least a part of transistors and diodes complying with the required specification of the power module are mounted on the substrate, and necessary jumper means are provided.

[0012] In a power module for AC/AC power conversion of a fifth aspect, the three phase converter comprises transistors serially connected to one another and a pair of first diodes reversely connected for each phase, and a diode bridge having a pair of connection points opposing to one another, each of the connection points being connected to the emitter terminal of the transistor and the collector terminal of the transistor, and having another pair of connection points which are determined to be input and output points, at least a part of transistors, the diode bridge, and the first diodes complying with the required specification of the power module are mounted on the substrate, and necessary jumper means are provided.

[0013] In a power module for AC/AC power conversion of a sixth aspect, the three phase converter comprises transistors serially connected to one another and a pair of first diodes reversely connected for each phase, and a diode bridge having a pair of connection points opposing to one another, each of the connection points being connected to the emitter terminal of the transistor and the collector terminal of the transistor, and having another pair of connection points which are determined to be input and output points, only at least a part of first diodes complying with the required specification of the power module are mounted on the substrate, and necessary jumper means are provided.

[0014] In a power module for AC/AC power conversion of a seventh aspect, the three phase converter comprises transistors serially connected to one another and a pair of first diodes reversely connected for each phase, and a diode bridge having a pair of connection points opposing to one another, each of the connection points being connected to the emitter

terminal of the transistor and the collector terminal of the transistor, and having another pair of connection points which are determined to be input and output points, at least a part of transistors and the diode bridge complying with the required specification of the power module are mounted on the substrate, at least a part of first diodes complying with the required specification of the power module are mounted on the substrate, and necessary jumper means are provided.

[0015] In a power module for AC/AC power conversion of an eighth aspect, the three phase converter comprises transistors serially connected to one another and a pair of first diodes forwardly connected for each phase, and pairs of second diodes each reversely connected between the emitter terminal of the transistor and the collector terminal of the transistor, each pair of second diodes being serially connected to one another, at least a part of transistors and second diodes complying with the required specification of the power module are mounted on the substrate, at least a part of first diodes complying with the required specification of the power module are mounted on the substrate, and necessary jumper means are provided.

[0016] In a power module for AC/AC power conversion of a ninth aspect, the three phase converter comprises transistors serially connected to one another and a pair of first diodes forwardly connected for each phase, and pairs of second diodes each reversely connected between the emitter terminal of the transistor and the collector terminal of the transistor, each pair of second diodes being serially connected to one another, only at least a part of first diodes complying with the required specification of the power module are mounted on the substrate, and necessary jumper means are provided.

[0017] In a power module for AC/AC power conversion of a tenth aspect, only at least a part of diodes are mounted on the substrate, and a reactor is connected outside of the exterior between the converter and the smoothing ~~condenser~~ capacitor.

[0018] In a power module for AC/AC power conversion of an eleventh aspect, only at least a part of first diodes are mounted on the substrate, and a reactor is connected outside of the exterior between the converter and the smoothing ~~condenser~~ capacitor. In a power module for AC/AC power conversion of a twelfth aspect, a reactor is connected in parallel to the converter, and a third diode is reversely connected between the reactor and the smoothing ~~condenser~~ capacitor. In a power module for AC/AC power conversion of a thirteenth aspect, a fourth diode is forwardly connected in parallel to the converter, and a reactor is connected

between the fourth diode and the smoothing ~~condenser~~ capacitor. A power module for AC/AC power conversion of a fourteenth aspect is a power module in which multiple converter components constituting a multiple phase converter, and multiple inverter components constituting a multiple phase inverter can be mounted on a substrate which has been formed necessary wirings,

[0019] the power module is arranged in that at least a part of converter components, at least a part of smoothing ~~condensers~~ capacitors, and at least a part of inverter components complying with required specification of the power module are mounted on the substrate, and that necessary jumper means are provided.

[0020] A power module for AC/AC power conversion of a fifteenth aspect further comprises junction means to which a smoothing ~~condenser~~ capacitor can be connected.

[0021] A power module for AC/AC power conversion of a sixteenth aspect employs a three phase converter as the multiple phase converter which can be mounted on the substrate, and employs a three phase inverter as the multiple phase inverter which can be mounted on the substrate. In a power module for AC/AC power conversion of a seventeenth aspect, a three phase converter comprising a pair of transistors serially connected to one another for each phase, and diodes each connected in parallel to each transistor, is employed as the three phase converter, at least a part of diodes and/or at least a part of transistors and diodes complying with required specification of the power module are mounted on the substrate, and necessary jumper means are provided.

[0022] In a power module for AC/AC power conversion of an eighteenth aspect, a three phase converter comprising a pair of transistors serially connected to one another for each phase, and diodes each connected in parallel to each transistor, is employed as the three phase inverter, at least a part of transistors and diodes complying with required specification of the power module are mounted on the substrate, and necessary jumper means are provided.

[0023] In a power module for AC/AC power conversion of a nineteenth aspect, a three phase converter comprising transistors serially connected to one another and a pair of first diodes reversely connected for each phase, and a diode bridge having a pair of connection points opposing to one another, each of the connection points being connected to the emitter terminal of the transistor and the collector terminal of the transistor, and having another pair of connection points which are determined to be input and output points, is employed as the

three phase converter, at least a part of transistors, the diode bridge, and the first diodes complying with the required specification of the power module are mounted on the substrate, and necessary jumper means are provided.

[0024] In a power module for AC/AC power conversion of a twentieth aspect, a three phase converter comprising transistors serially connected to one another and a pair of first diodes reversely connected for each phase, and a diode bridge having a pair of connection points opposing to one another, each of the connection points being connected to the emitter terminal of the transistor and the collector terminal of the transistor, and having another pair of connection points which are determined to be input and output points, is employed as the three phase converter, only at least a part of first diodes complying with the required specification of the power module are mounted on the substrate, and necessary jumper means are provided.

[0025] In a power module for AC/AC power conversion -of a 21 st aspect, a three phase converter comprising transistors serially connected to one another and a pair of first diodes reversely connected for each phase, and a diode bridge having a pair of connection points opposing to one another, each of the connection points being connected to the emitter terminal of the transistor and the collector terminal of the transistor, and having another pair of connection points which are determined to be input and output points, is employed as the three phase converter, at least a part of transistors and the diode bridge complying with the required specification of the power module are mounted on the substrate, at least a part of first diodes complying with the required specification of the power module are mounted on the substrate, and necessary jumper means are provided.

[0026] In a power module for AC/AC power conversion of a 22nd aspect, a three phase converter comprises transistors serially connected to one another and a pair of first diodes forwardly connected for each phase, and pairs of second diodes each reversely connected between the emitter terminal of the transistor and the collector terminal of the transistor, each pair of second diodes being serially connected to one another, is employed as the three phase converter, at least a part of transistors and second diodes complying with the required specification of the power module are mounted on the substrate, at least a part of first diodes complying with the required specification of the power module are mounted on the substrate, and necessary jumper means are provided.

[0027] In a power module for AC/AC power conversion of a 23rd aspect, a three phase

converter comprising transistors serially connected to one another and a pair of first diodes forwardly connected for each phase, and pairs of second diodes each reversely connected between the emitter terminal of the transistor and the collector terminal of the transistor, each pair of second diodes being serially connected to one another, is employed as the three phase converter, only at least a part of first diodes complying with the required specification of the power module are mounted on the substrate, and necessary jumper means are provided.

[0028] In a power module for AC/AC power conversion of a 24th or 25th aspect, only at least a part of diodes are mounted on the substrate, and junction means are provided for allowing the reactor being connected between the converter and the smoothing ~~condenser~~ capacitor.

[0029] In a power module for AC/AC power conversion of a 26th aspect, only at least a part of first diodes are mounted on the substrate, and junction means are provided for allowing the reactor being connected between the converter and the smoothing ~~condenser~~ capacitor.

[0030] In a power module for AC/AC power conversion of a 27th aspect, a reactor is connected in parallel to the converter, and a third diode is reversely connected between the reactor and the smoothing ~~condenser~~ capacitor.

[0031] In a power module for AC/AC power conversion of a 28th aspect, a fourth diode is forwardly connected in parallel to the converter, and a reactor is connected between the fourth diode and the smoothing ~~condenser~~ capacitor. In the power module for AC/AC power conversion of the first aspect, multiple converter components constituting the multiple phase converter, multiple smoothing ~~condensers~~ capacitors, and multiple inverter components constituting the multiple phase inverter can be mounted on the substrate which has been formed necessary wirings, and the power module is arranged in that at least a part of converter components, at least a part of smoothing ~~condensers~~ capacitors, and at least a part of inverter components complying with required specification of the power module are mounted on the substrate, and that necessary jumper means are provided. Therefore, various power modules such as a power module for multiple phase - multiple phase conversion, a power module for single phase - multiple phase conversion, and the like, can easily be realized.

[0032] In the power module for AC/AC power conversion of the second aspect, the three phase converter is employed as the multiple phase converter, the number of smoothing

~~condensers~~ capacitors is determined to be 2, and the three phase inverter is employed as the multiple phase inverter. Therefore, various power modules such as a power module for three phase - three phase conversion, a power module for single phase - three phase conversion, and the like, can easily be realized.

[0033] In the power module for AC/AC power conversion of the third aspect, the three phase converter comprises the pair of transistors serially connected to one another for each phase, and diodes each connected in parallel to each transistor, at least a part of diodes and/or at least a part of transistors and diodes complying with the required specification of the power module are mounted on the substrate, and necessary jumper means are provided. Therefore, various power modules such as a power module for three phase - three phase conversion, a power module for single phase - three phase conversion, and the like, can easily be realized.

[0034] In the power module for AC/AC power conversion of the fourth aspect, the three phase converter comprises the pair of transistors serially connected to one another for each phase, and reflux diodes each connected in parallel to each of the transistors, at least a part of diodes and/or at least a part of transistors and diodes complying with the required specification of the power module are mounted on the substrate, and necessary jumper means are provided. Therefore, various power module can also and easily be realized which can satisfy the IEC regulation for harmonic current emissions.

[0035] In the power module for AC/AC power conversion of the fifth aspect, the three phase converter comprises transistors serially connected to one another and the pair of first diodes reversely connected for each phase, and the diode bridge having the pair of connection points opposing to one another, each of the connection points being connected to the emitter terminal of the transistor and the collector terminal of the transistor, and having another pair of connection points which are determined to be input and output points, at least a part of transistors, the diode bridge, and the first diodes complying with the required specification of the power module are mounted on the substrate, and necessary jumper means are provided. Therefore, various power module can also and easily be realized which can satisfy the IEC regulation for harmonic current emissions.

[0036] In the power module for AC/AC power conversion of the sixth aspect, the three phase converter comprises transistors serially connected to one another and the pair of first diodes reversely connected for each phase, and the diode bridge having the pair of

connection points opposing to one another, each of the connection points being connected to the emitter terminal of the transistor and the collector terminal of the transistor, and having another pair of connection points which are determined to be input and output points, only at least a part of first diodes complying with the required specification of the power module are mounted on the substrate, and necessary jumper means are provided. Therefore, various power modules such as a power module for three phase - three phase conversion, a power module for single phase - three phase conversion, and the like, can easily be realized.

[0037] In the power module for AC/AC power conversion of the seventh aspect, the three phase converter comprises transistors serially connected to one another and the pair of first diodes reversely connected for each phase, and the diode bridge having the pair of connection points opposing to one another, each of the connection points being connected to the emitter terminal of the transistor and the collector terminal of the transistor, and having another pair of connection points which are determined to be input and output points, at least a part of transistors and the diode bridge complying with the required specification of the power module are mounted on the substrate, at least a part of first diodes complying with the required specification of the power module are mounted on the substrate, and necessary jumper means are provided. Therefore, various power module can also and easily be realized which can satisfy the IEC regulation for harmonic current emissions.

[0038] In the power module for AC/AC power conversion of the eighth aspect, the three phase converter comprises transistors serially connected to one another and the pair of first diodes forwardly connected for each phase, and pairs of second diodes each reversely connected between the emitter terminal of the transistor and the collector terminal of the transistor, each pair of second diodes being serially connected to one another, at least a part of transistors and second diodes complying with the required specification of the power module are mounted on the substrate, at least a part of first diodes complying with the required specification of the power module are mounted on the substrate, and necessary jumper means are provided. Therefore, various power module can also and easily be realized which can satisfy the IEC regulation for harmonic current emissions.

[0039] In the power module for AC/AC power conversion of the ninth aspect, the three phase converter comprises transistors serially connected to one another and the pair of first diodes forwardly connected for each phase, and pairs of second diodes each reversely connected between the emitter terminal of the transistor and the collector terminal of the

transistor, each pair of second diodes being serially connected to one another, only at least a part of first diodes complying with the required specification of the power module are mounted on the substrate, and necessary jumper means are provided. Therefore, various power modules such as a power module for three phase - three phase conversion, a power module for single phase - three phase conversion, and the like, can easily be realized.

[0040] In the power module for AC/AC power conversion of the tenth aspect, only at least a part of diodes are mounted on the substrate, and the reactor is connected outside of the exterior between the converter and the smoothing ~~condenser~~ capacitor. Therefore, harmonic components of power source are reduced by the reactor. Also, operations and effects similar to those of the third aspect and sixth aspect can be realized.

[0041] In the power module for AC/AC power conversion of the eleventh aspect, only at least a part of first diodes are mounted on the substrate, and the reactor is connected outside of the exterior between the converter and the smoothing ~~condenser~~ capacitor. Therefore, harmonic components of power source are reduced by the reactor. Also, operations and effects similar to those of the ninth aspect can be realized.

[0042] In the power module for AC/AC power conversion of the twelfth aspect, the reactor is connected in parallel to the converter, and the third diode is reversely connected between the reactor and the smoothing ~~condenser~~ capacitor. Therefore, step up-down in voltage can be realized. Also, operations and effects similar to those of the eighth aspect can be realized.

[0043] In the power module for AC/AC power conversion of the thirteenth aspect, the fourth diode is forwardly connected in parallel to the converter, and the reactor is connected between the fourth diode and the smoothing ~~condenser~~ capacitor. Therefore, stepping-down in voltage can be realized. Also, operations and effects similar to those of the eighth aspect can be realized.

[0044] In the power module for AC/AC power conversion of the fourteenth aspect, multiple converter components constituting a multiple phase converter, and multiple inverter components constituting a multiple phase inverter can be mounted on the substrate which has been formed necessary wirings, and at least a part of converter components, at least a part of smoothing ~~condensers~~ capacitors, and at least a part of inverter components complying with required specification of the power module are mounted on the substrate, and the necessary jumper means are provided. Therefore, various power modules such as a

power module for multiple phase - multiple phase conversion, a power module for single phase - multiple phase conversion, and the like, can easily be realized.

[0045] In the power module for AC/AC power conversion of the fifteenth aspect, the junction means is further comprised to which a smoothing ~~condenser~~ capacitor can be connected. Therefore, the power module can be dealt with a case where a smoothing ~~condenser~~ capacitor is required. Also, operations and effects similar to those of the fourteenth aspect can be realized.

[0046] In the power module for AC/AC power conversion of the sixteenth aspect, the three phase converter is employed as the multiple phase converter which can be mounted on the substrate, and the three phase inverter is employed as the multiple phase inverter which can be mounted on the substrate. Therefore, various power modules such as a power module for three phase - three phase conversion, a power module for single phase - three phase conversion, and the like, can easily be realized.

[0047] In the power module for AC/AC power conversion of the seventeenth aspect, the three phase converter comprising the pair of transistors serially connected to one another for each phase, and the diodes each connected in parallel to each transistor, is employed as the three phase converter, at least a part of diodes and/or at least a part of transistors and diodes complying with required specification of the power module are mounted on the substrate, and necessary jumper means are provided. Therefore, various power modules such as a power module for three phase - three phase conversion, a power module for single phase - three phase conversion, and the like, can easily be realized.

[0048] In the power module for AC/AC power conversion of the eighteenth aspect, a three phase converter comprising the pair of transistors serially connected to one another for each phase, and diodes each connected in parallel to each transistor, is employed as the three phase inverter, at least a part of transistors and diodes complying with required specification of the power module are mounted on the substrate, and necessary jumper means are provided. Therefore, various power module can also and easily be realized which can satisfy the IEC regulation for harmonic current emissions.

[0049] In the power module for AC/AC power conversion of the nineteenth aspect, the three phase converter comprising transistors serially connected to one another and the pair of first diodes reversely connected for each phase, and the diode bridge having the pair of connection points opposing to one another, each of the connection points being connected to

the emitter terminal of the transistor and the collector terminal of the transistor, and having another pair of connection points which are determined to be input and output points, is employed as the three phase converter, at least a part of transistors, the diode bridge, and the first diodes complying with the required specification of the power module are mounted on the substrate, and necessary jumper means are provided. Therefore, various power module can also and easily be realized which can satisfy the IEC regulation for harmonic current emissions.

[0050] In the power module for AC/AC power conversion of the twentieth aspect, the three phase converter comprising transistors serially connected to one another and the pair of first diodes reversely connected for each phase, and the diode bridge having the pair of connection points opposing to one another, each of the connection points being connected to the emitter terminal of the transistor and the collector terminal of the transistor, and having another pair of connection points which are determined to be input and output points, is employed as the three phase converter, only at least a part of first diodes complying with the required specification of the power module are mounted on the substrate, and necessary jumper means are provided. Therefore, various power modules such as a power module for three phase - three phase conversion, a power module for single phase - three phase conversion, and the like, can easily be realized.

[0051] In the power module for AC/AC power conversion of the 21st aspect, the three phase converter comprising transistors serially connected to one another and the pair of first diodes reversely connected for each phase, and the diode bridge having the pair of connection points opposing to one another, each of the connection points being connected to the emitter terminal of the transistor and the collector terminal of the transistor, and having another pair of connection points which are determined to be input and output points, is employed as the three phase converter, at least a part of transistors and the diode bridge complying with the required specification of the power module are mounted on the substrate, at least a part of first diodes complying with the required specification of the power module are mounted on the substrate, and necessary jumper means are provided. Therefore, various power module can also and easily be realized which can satisfy the IEC regulation for harmonic current emissions.

[0052] In the power module for AC/AC power conversion of the 22nd aspect, the three phase converter comprises transistors serially connected to one another and the pair of first

diodes forwardly connected for each phase, and pairs of second diodes each reversely connected between the emitter terminal of the transistor and the collector terminal of the transistor, each pair of second diodes being serially connected to one another, is employed as the three phase converter, at least a part of transistors and second diodes complying with the required specification of the power module are mounted on the substrate, at least a part of first diodes complying with the required specification of the power module are mounted on the substrate, and necessary jumper means are provided. Therefore, various power module can also and easily be realized which can satisfy the IEC regulation for harmonic current emissions.

[0053] In the power module for AC/AC power conversion of the 23rd aspect, the three phase converter comprising transistors serially connected to one another and the pair of first diodes forwardly connected for each phase, and pairs of second diodes each reversely connected between the emitter terminal of the transistor and the collector terminal of the transistor, each pair of second diodes being serially connected to one another, is employed as the three phase converter, only at least a part of first diodes complying with the required specification of the power module are mounted on the substrate, and necessary jumper means are provided. Therefore, various power modules such as a power module for three phase - three phase conversion, a power module for single phase - three phase conversion, and the like, can easily be realized.

[0054] In the power module for AC/AC power conversion of the 24th or 25th aspect, only at least a part of diodes are mounted on the substrate, and, junction means are provided for allowing the reactor being connected between the converter and the smoothing ~~condenser~~ capacitor. Therefore, harmonic components of power source are reduced by the reactor. Also, operations and effects similar to those of the seventeenth aspect and twentieth aspect can be realized.

[0055] In the power module for AC/AC power conversion of the 26th aspect, only at least a part of first diodes are mounted on the substrate, and junction means are provided for allowing the reactor being connected between the converter and the smoothing ~~condenser~~ capacitor. Therefore, harmonic components of power source are reduced by the reactor. Also, operations and effects similar to those of the 23rd aspect can be realized.

[0056] In the power module for AC/AC power conversion of the 27th aspect, the reactor is connected in parallel to the converter, and the third diode is reversely connected between

the reactor and the smoothing ~~condenser~~ capacitor. Therefore, step up-down in voltage can be realized. Also, operations and effects similar to those of the 22nd aspect can be realized.

[0057] In the power module for AC/AC power conversion of the 28th aspect, the fourth diode is forwardly connected in parallel to the converter, and the reactor is connected between the fourth diode and the smoothing ~~condenser~~ capacitor. Therefore, stepping-down in voltage can be realized. Also, operations and effects similar to those of the 22nd aspect can be realized.

Brief Description of the Drawings

[0058] Figure 1 is an electric circuit diagram illustrating a conventional three phase - three phase power module;

[0059] Figure 2 is a block diagram illustrating a conventional active filter power module;

[0060] Figure 3 is an electric circuit diagram illustrating a basic topology of a first type of a power module;

[0061] Figure 4 is a schematic diagram of an arrangement example of a first type of a power module;

[0062] Figure 5 is a schematic diagram of another arrangement example of a first type of a power module;

[0063] Figure 6 is a schematic diagram of a further arrangement example of a first type of a power module;

[0064] Figure 7 is a schematic diagram of a further arrangement example of a first type of a power module;

[0065] Figure 8 is a schematic diagram of a further arrangement example of a first type of a power module;

[0066] Figure 9 is a schematic diagram of a further arrangement example of a first type of a power module;

[0067] Figure 10 is a schematic diagram of a further arrangement example of a first type of a power module;

[0068] Figure 11 is a schematic diagram of a further arrangement example of a first type of a power module;

[0069] Figure 12 is a schematic diagram of a further arrangement example of a first type of a power module;

[0070] Figure 13 is an electric circuit diagram illustrating a basic topology of a second

type of a power module;

[0071] Figure 14 is a schematic diagram of an arrangement example of a second type of a power module;

[0072] Figure 15 is a schematic diagram of another arrangement example of a second type of a power module;

[0073] Figure 16 is a schematic diagram of a further arrangement example of a second type of a power module;

[0074] Figure 17 is a schematic diagram of a further arrangement example of a second type of a power module;

[0075] Figure 18 is a schematic diagram of a further arrangement example of a second type of a power module;

[0076] Figure 19 is a schematic diagram of a further arrangement example of a second type of a power module;

[0077] Figure 20 is a schematic diagram of a further arrangement example of a second type of a power module;

[0078] Figure 21 is an electric circuit diagram illustrating a basic topology of a third type of a power module;

[0079] Figure 22 is a schematic diagram of an arrangement example of a third type of a power module;

[0080] Figure 23 is a schematic diagram of another arrangement example of a third type of a power module;

[0081] Figure 24 is a schematic diagram of a further arrangement example of a third type of a power module;

[0082] Figure 25 is a schematic diagram of a further arrangement example of a third type of a power module;

[0083] Figure 26 is a schematic diagram of a further arrangement example of a third type of a power module;

[0084] Figure 27 is a schematic diagram of a further arrangement example of a third type of a power module;

[0085] Figure 28 is a schematic diagram of a further arrangement example of a third type of a power module;

[0086] Figure 29 is a schematic diagram of a further arrangement example of a third type

of a power module;

[0087] Figure 30 is a schematic diagram of a further arrangement example of a third type of a power module;

[0088] Figure 31 is a schematic diagram of a further arrangement example of a third type of a power module;

[0089] Figure 32 is a schematic diagram of a modified example of the power module illustrated in Fig. 4;

[0090] Figure 33 is a schematic diagram of a modified example of the power module illustrated in Fig. 5;

[0091] Figure 34 is a schematic diagram of a modified example of the power module illustrated in Fig. 6;

[0092] Figure 35 is a schematic diagram of a modified example of the power module illustrated in Fig. 7;

[0093] Figure 36 is a schematic diagram of a modified example of the power module illustrated in Fig. 8;

[0094] Figure 37 is a schematic diagram of a modified example of the power module illustrated in Fig. 9;

[0095] Figure 38 is a schematic diagram of a modified example of the power module illustrated in Fig. 10;

[0096] Figure 39 is a schematic diagram of a modified example of the power module illustrated in Fig. 11;

[0097] Figure 40 is a schematic diagram of a modified example of the power module illustrated in Fig. 12;

[0098] Figure 41 is a schematic diagram of a modified example of the power module illustrated in Fig. 14;

[0099] Figure 42 is a schematic diagram of a modified example of the power module illustrated in Fig. 15;

[00100] Figure 43 is a schematic diagram of a modified example of the power module illustrated in Fig. 16;

[00101] Figure 44 is a schematic diagram of a modified example of the power module illustrated in Fig. 17;

[00102] Figure 45 is a schematic diagram of a modified example of the power module

illustrated in Fig. 18;

[00103] Figure 46 is a schematic diagram of a modified example of the power module illustrated in Fig. 19;

[00104] Figure 47 is a schematic diagram of a modified example of the power module illustrated in Fig. 20;

[00105] Figure 48 is a schematic diagram of a modified example of the power module illustrated in Fig. 22;

[00106] Figure 49 is a schematic diagram of a modified example of the power module illustrated in Fig. 23;

[00107] Figure 50 is a schematic diagram of a modified example of the power module illustrated in Fig. 24;

[00108] Figure 51 is a schematic diagram of a modified example of the power module illustrated in Fig. 26;

[00109] Figure 52 is a schematic diagram of a modified example of the power module illustrated in Fig. 27;

[00110] Figure 53 is a schematic diagram of a modified example of the power module illustrated in Fig. 28;

[00111] Figure 54 is a schematic diagram of a modified example of the power module illustrated in Fig. 29.

Detailed Description of the Preferred Embodiments

[00112] Hereinafter, referring to the attached drawings, we describe in detail a power module for AC/AC power conversion of an embodiment according to the present invention.

[00113] The present invention comprises three types of power modules for AC/AC power conversion.

(A) A first type of power module is based upon boost type topology.

(B) A second type of power module is based upon boost three level type topology.

(C) A third type of power module is based upon buck/boost current source type topology.

[00114] Each of the proposed three power modules can be used in different situation by adding/removing respective necessary/unnecessary individual device.

(A) The first type:

[00115] Fig. 3 illustrates a basic power conversion module for converting a three phase AC power source with a constant voltage and constant frequency into a three phase AC

output power source with a variable voltage and variable frequency control system. The basic power conversion module comprises an AC/DC conversion section (converter) 10, a DC/AC conversion section (inverter) 20, a smoothing ~~condenser~~ capacitor 5 connected between the converter 10 and the inverter 20, and reactors 6 each connected between the connection point of each pair of IGBT switches 1 of the converter 10 and the output terminal of each phase of the AC power source. And, a ~~condenser~~ capacitor 7 is connected between the input terminals, as it is required.

[00116] The AC/DC conversion section (converter) 10 comprises three pairs of IGBT switches 1, each pair of IGBT switches being serially connected to one another and each pair of IGBT switches being connected in parallel to one another, and first diodes 2 each being connected in reversed polarity and in parallel to each IGBT switch 1.

[00117] The DC/AC conversion section (inverter) 20 comprises three pairs of IGBT switches 3, each pair of IGBT switches being serially connected to one another and each pair of IGBT switches being connected in parallel to one another, and diodes 4 each being connected in reversed polarity and in parallel to each IGBT switch 3.

[00118] As is illustrated in Fig. 4, the proposed three phase - three phase system is integrated into one module using surface mounted IGBT devices similar to the integrated IGBT standard module. The surface mounted IGBT device is designed according to the input and output requirements indicated in Table 1.

		Load side	
		200V	400V
Power source side	200V (Japan)	Possible	Possible
	400V (Europe)	Impossible	Possible

[00119] The proposed three phase - three phase power module can be modified by changing only the type of a surface mounted power device according to the requirement of the following specific applications. A thick solid line represents a jumper line in each of the following figures.

(1) A three phase - three phase power module of Fig. 4 is constituted of 12 surface mounted diodes 2, 4 and surface mounted IGBT switches 1, 3. A surface mounted smoothing ~~condenser~~ capacitor 5 on one side is omitted. By controlling the IGBT switches 1, 3, the

harmonic component currents in grid side is reduced, the DC link voltage is controlled, and the power is regenerated from the load to the power source.

[00120] A three phase - three phase power module of Fig. 32 is different from the three phase - three phase power module of Fig. 4 only in that the smoothing ~~condenser~~ capacitor 5 is connected from outside through junction sections (lead wires). Therefore, by controlling the IGBT switches 1, 3, the harmonic component currents in grid side is reduced, the DC link voltage is controlled, and the power is regenerated from the load to the power source.

(2) A three phase - three phase power module of Fig. 7 is consisted of 6 surface mounted diodes 2 on grid side as a converter 10, and 4 surface mounted diodes 4 and surface mounted IGBT switches 3 on load side as an inverter 20. The arrangement is employed for applications which take only efficiency into consideration. A reactor 8 is connected from outside between the converter 10 and the smoothing ~~condenser~~ capacitor 5 instead connecting the reactor 6 on the input side of the converter 10.

[00121] A three phase - three phase power module of Fig. 35 is different from the three phase - three phase power module of Fig. 7 only in that the smoothing ~~condenser~~ capacitor 5 is connected from outside through junction sections (lead wires). Therefore, the arrangement is also employed for applications which take only efficiency into consideration.

(3) A three phase -three phase power module of Fig. 5 is consisted of 10 surface mounted IGBT switches 1, 3. 6 IGBT switches among 10 IGBT switches are in a converter 10 on grid side, while remaining 4 IGBT switches 3 are in an inverter 20 on load side. By controlling the IGBT switches 1, 3, the harmonic component currents in grid side is reduced, the DC link voltage is controlled, and the power is regenerated from the load to the power source.

[00122] Also, the switching loss is reduced and the efficiency is increased by decreasing the IGBT switches 3 on load side by 2.

[00123] A three phase - three phase power module of Fig. 33 is different from the three phase - three phase power module of Fig. 5 only in that the smoothing ~~condenser~~ capacitor 5 is connected from outside through junction sections (lead wires).

[00124] Therefore, by controlling the IGBT switches 1, 3, the harmonic component currents in grid side is reduced, the DC link voltage is controlled, and the power is regenerated from the load to the power source.

[00125] Also, the switching loss is reduced and the efficiency is increased by decreasing

the IGBT switches 3 on load side by 2.

(4) A three phase - three phase power module of Fig. 6 is consisted of 8 surface mounted IGBT switches 1, 3. 4 IGBT switches among 8 IGBT switches are in a converter 10 on grid side, while remaining 4 IGBT switches 3 are in an inverter 20 on load side. The voltage multiplying operation can be carried out because 2 smoothing ~~condensers~~ capacitors 5 are serially connected to one another.

[00126] By controlling the IGBT switches 1, 3, the harmonic component currents in grid side is reduced, the DC link voltage is controlled, and the power is regenerated from the load to the power source.

[00127] Also, the switching loss is reduced and the efficiency is increased by decreasing the IGBT switches 3 on load side and load side by 4. A three phase - three phase power module of Fig. 34 is different from the three phase - three phase power module of Fig. 6 only in that the smoothing ~~condenser~~ capacitor 5 is connected from outside through junction sections (lead wires).

[00128] Therefore, by controlling the IGBT switches 1, 3, the harmonic component currents in grid side is reduced, the DC link voltage is controlled, and the power is regenerated from the load to the power source.

[00129] Also, the switching loss is reduced and the efficiency is increased by decreasing the IGBT switches 3 on load side and load side by 4.

[00130] The above three phase - three phase power module can be modified into a single phase - three phase power module by changing only the type of a surface mounted power device according to the requirement of the following specific applications.

(1) A single phase - three phase power module of Fig. 8 is constituted of 4 surface mounted diodes 2 of a converter 10 on grid side, and 6 surface mounted diodes 4 and 6 surface mounted IGBT switches 3 of an inverter 20 on load side. As is illustrated in Fig. 8, the power module uses the voltage doubling topology to increase the output voltage (a pair of surface mounted smoothing ~~condensers~~ capacitors 5 are serially connected to one another). The single phase - three phase power module is employed for applications in which input power source is low (for example, 100V in Japan) and the IEC regulation is not effective. A reactor 8 is connected from outside between the converter 10 and the smoothing ~~condenser~~ capacitor 5 instead connecting the reactor 6 on the input side of the converter 10.

[00131] A single phase - three phase power module of Fig. 36 is different from the single

phase - three phase power module of Fig. 8 only in that the smoothing ~~condenser~~ capacitor 5 is connected from outside through junction sections (lead wires). Therefore, the single phase - three phase power module is employed for applications in which input power source is low (for example, 100V in Japan) and the IEC regulation is not effective.

(2) A single phase - three phase power module of Fig. 9 is constituted of 4 surface mounted diodes 2 of a converter 10 on grid side, and 6 surface mounted diodes 4 and 6 surface mounted IGBT switches 3 of an inverter 20 on load side.

[00132] Therefore, the single phase - three phase power module is employed for applications in which the IEC regulation is not effective. A reactor 8 is connected from outside between the converter 10 and the smoothing ~~condenser~~ capacitor 5 instead connecting the reactor 6 on the input side of the converter 10.

[00133] A single phase - three phase power module of Fig. 37 is different from the single phase - three phase power module of Fig. 9 only in that the smoothing ~~condenser~~ capacitor 5 is connected from outside through junction sections (lead wires). Therefore, the single phase - three phase power module is employed for applications in which the IEC regulation is not effective. A reactor 8 is connected from outside between the converter 10 and the smoothing ~~condenser~~ capacitor 5 instead connecting the reactor 6 on the input side of the converter 10.

(3) A single phase - three phase power module of Fig. 10 is constituted of 2 surface mounted diodes 2 and 2 surface mounted IGBT switches 1 of a converter 10 on grid side, and 6 surface mounted diodes 4 and 6 surface mounted IGBT switches 3 of an inverter 20 on load side. As is illustrated in Fig. 10, the power module uses the voltage doubling topology to increase the output voltage (a pair of surface mounted smoothing ~~condensers~~ capacitors 5 are serially connected to one another). The single phase-three phase power module is employed for applications in which input power source is low (for example, 100V in Japan) and the IEC regulation is effective.

[00134] A single phase - three phase power module of Fig. 38 is different from the single phase - three phase power module of Fig. 10 only in that the smoothing ~~condenser~~ capacitor 5 is connected from outside through junction sections (lead wires). Therefore, the single phase - three phase power module is employed for applications in which input power source is low (for example, 100V in Japan) and the IEC regulation is effective.

(4) A single phase - three phase power module of Fig. 11 is constituted of 4 surface mounted IGBT switches 1 and 4 surface mounted diodes 2 of a converter 10 on grid side,

and 6 surface mounted diodes 4 and 6 surface mounted IGBT switches 3 of an inverter 20 on load side.

[00135] Therefore, the single phase - three phase power module is employed for applications in which the IEC regulation is not effective.

[00136] A single phase - three phase power module of Fig. 39 is different from the single phase - three phase power module of Fig. 11 only in that the smoothing ~~condenser~~ capacitor 5 is connected from outside through junction sections (lead wires). Therefore, the single phase - three phase power module is employed for applications in which the IEC regulation is not effective.

(5) A single phase - three phase power module of Fig. 12 is constituted of 2 surface mounted diodes 2 and 2 surface mounted IGBT switches 1 of a converter 10 on grid side, and 4 surface mounted diodes 4 and 4 surface mounted IGBT switches 3 of an inverter 20 on load side. As is illustrated in Fig. 12, the power module uses the voltage doubling topology to increase the output voltage (a pair of surface mounted smoothing ~~condensers~~ capacitors 5 are serially connected to one another). The single phase - three phase power module is employed for applications in which input power source is low (for example, 100V in Japan) and the IEC regulation is effective.

[00137] A single phase - three phase power module of Fig. 40 is different from the single phase - three phase power module of Fig. 12 only in that the smoothing ~~condenser~~ capacitor 5 is connected from outside through junction sections (lead wires). Therefore, the single phase - three phase power module is employed for applications in which input power source is low (for example, 100V in Japan) and the IEC regulation is effective.

[00138] Fig. 13 illustrates a basic power conversion module for converting a three phase AC power source with a constant voltage and constant frequency into a three phase AC output power source with a variable voltage and variable frequency control system. In the basic power conversion module, a converter 10 on grid side is constituted of serially connection of one IGBT switch 11 and two reverse connection diodes 12 for each phase, and providing a diode bridge 13 which is connected its one pair of opposing connection points to the emitter terminal, collector terminal of the IGBT switch 11 and is determined its another pair of opposing connection points to be an input terminal, output terminal. And, a pair of smoothing ~~condensers~~ capacitors 5 are serially connected to one another for carrying out the voltage multiplying operation. An arrangement of an inverter 20 on load side is the same as

that of the power module of Fig. 4. Therefore, description of the inverter 20 is omitted.

[00139] As is illustrated in Fig. 14, the proposed three phase - three phase system is integrated into one module using surface mounted IGBT devices similar to the integrated IGBT standard module. The surface mounted IGBT device is designed according to the input and output requirements indicated in Table 2.

		Load side	
		200V motor	400V motor
Power source side	200V (Japan)	Possible	Possible
	400V (Europe)	Possible	Possible

[00140] The proposed three phase - three phase power module can be modified by changing only the type of a surface mounted power device according to the requirement of the following specific applications.

(1) A three phase - three phase power module of Fig. 14 is constituted of 18 surface mounted diodes 12, 13 and 3 surface mounted IGBT switches 11 of a converter on grid side, and 6 surface mounted diodes 4 and 6 surface mounted IGBT switches 3 of an inverter 20 on load side. By controlling the surface mounted IGBT 11, the harmonic component currents on grid side are reduced, and the DC link voltage is controlled to reduce the rated current of the IGBT switch 11 of the inverter 20 on load side. A three phase - three phase power module of Fig. 41 is different from the three phase - three phase power module of Fig. 14 only in that the smoothing ~~condenser~~ capacitor 5 is connected from outside through junction sections (lead wires). Therefore, by controlling the surface mounted IGBT 11, the harmonic component currents on grid side are reduced, and the DC link voltage is controlled to reduce the rated current of the IGBT switch 11 of the inverter 20 on load side.

(2) A three phase _ three phase power module of Fig. 15 is constituted of 6 surface mounted diodes 2 of a converter 10 on grid side, and 6 surface mounted diodes 4 and 6 surface mounted IGBT switches 3 of an inverter 20 on load side. The three phase - three phase power module is employed for applications which take only efficiency into consideration. A reactor 8 is connected from outside between the converter 10 and the smoothing ~~condenser~~capacitor 5 instead connecting the reactor 6 on the input side of the converter 10.

[00141] A three phase - three phase power module of Fig. 42 is different from the three phase - three phase power module of Fig. 15 only in that the smoothing ~~condenser~~ capacitor 5 is connected from outside through junction sections (lead wires). Therefore, the three phase - three phase power module is employed for applications which take only efficiency into consideration. A reactor 8 is connected from outside between the converter 10 and the smoothing ~~condenser~~ capacitor 5 instead connecting the reactor 6 on the input side of the converter 10.

(3) A three phase - three phase power module of Fig. 16 is constituted of 18 surface mounted diodes 12, 13 and 3 surface mounted IGBT switches 11 of a converter 10 on grid side, and 4 surface mounted diodes 4 and 4 surface mounted IGBT switches 3 of an inverter 20 on load side, and a pair of smoothing ~~condensers~~ capacitors 5 for voltage doubling. By controlling 3 surface mounted IGBT 11, the harmonic component currents on grid side are reduced, and the DC link voltage is controlled to reduce the rated current of the IGBT switch of the inverter 20 on load side. And, the switching loss is reduced and the efficiency is increased by reducing the number of IGBT switches 3 of the inverter 20 on load side.

[00142] A three phase - three phase power module of Fig. 43 is different from the three phase - three phase power module of Fig. 16 only in that the smoothing ~~condenser~~ capacitor 5 is connected from outside through junction sections (lead wires). Therefore, by controlling 3 surface mounted IGBT 11, the harmonic component currents on grid side are reduced, and the DC link voltage is controlled to reduce the rated current of the IGBT switch of the inverter 20 on load side.

(4) A three phase - three phase power module of Fig. 17 is constituted of 12 surface mounted diodes 12, 13 and 2 surface mounted IGBT switches 11 of a converter 10 on grid side, and 6 surface mounted diodes 4 and 6 surface mounted IGBT switches 3 of an inverter 20 on load side, and a pair of smoothing ~~condensers~~ capacitors 5 for voltage doubling. By controlling 2 surface mounted IGBT 11, the harmonic component currents on grid side are reduced, and the DC link voltage is controlled to reduce the rated current of the IGBT switch of the inverter 20 on load side. And, the switching loss is reduced and the efficiency is increased by reducing the total number of active switches of the converter 10 on grid side.

[00143] A three phase - three phase power module of Fig. 44 is different from the three phase - three phase power module of Fig. 17 only in that the smoothing ~~condenser~~ capacitor 5 is connected from outside through junction sections (lead wires). Therefore, by controlling

2 surface mounted IGBT 11, the harmonic component currents on grid side are reduced, and the DC link voltage is controlled to reduce the rated current of the IGBT switch of the inverter 20 on load side. And, the switching loss is reduced and the efficiency is increased by reducing the total number of active switches of the converter 10 on grid side.

[00144] The three phase - three phase power module can be modified into a single phase - three phase power module by changing only the type of a surface mounted power device according to the requirement of the following specific applications.

(1) A single phase - three phase power module of Fig. 18 is constituted of 8 surface mounted diodes 12, 13 and one surface mounted IGBT switch 11 of a converter 10 on grid side, and 6 surface mounted diodes 4 and 6 surface mounted IGBT switches 3 of an inverter 20 on load side, and a pair of smoothing ~~condensers~~ capacitors 5 for voltage doubling. By controlling one surface mounted IGBT 11, the harmonic component currents on grid side are reduced, and the DC link voltage is controlled to reduce the rated current of the IGBT switch 3 and diode 4 of the inverter on load side. And, the single phase - three phase power module is employed for low input voltage applications in which the IEC regulation is effective.

[00145] A single phase - three phase power module of Fig. 45 is different from the single phase - three phase power module of Fig. 18 only in that the smoothing ~~condenser~~ capacitor 5 is connected from outside through junction sections (lead wires). Therefore, by controlling one surface mounted IGBT 11, the harmonic component currents on grid side are reduced, and the DC link voltage is controlled to reduce the rated current of the IGBT switch 3 and diode 4 of the inverter on load side. And, the single phase - three phase power module is employed for low input voltage applications in which the IEC regulation is effective.

(2) A single phase - three phase power module of Fig. 19 is constituted of 4 surface mounted diodes 12 of a converter 10 on grid side, and 6 surface mounted diodes and 6 surface mounted IGBT switches 3 of an inverter 20 on load side. Therefore, the single phase - three phase power module is employed for applications in which the IEC regulation is not effective. A reactor 8 is connected from outside between the converter 10 on grid side and the smoothing ~~condenser~~ capacitor 5 instead connecting the reactor 6 on the input side of the converter 10 on grid side.

[00146] A single phase - three phase power module of Fig. 46 is different from the single phase - three phase power module of Fig. 19 only in that the smoothing ~~condenser~~ capacitor 5 is connected from outside through junction sections (lead wires). Therefore, the single

phase - three phase power module is employed for applications in which the IEC regulation is not effective. A reactor 8 is connected from outside between the converter 10 on grid side and the smoothing ~~condenser~~ capacitor 5 instead connecting the reactor 6 on the input side of the converter 10 on grid side.

(3) A single phase - three phase power module of Fig. 20 is constituted of 8 surface mounted diodes 12, 13 and one surface mounted IGBT switch 11 of a converter 10 on grid side, and 4 surface mounted diodes 4 and 4 surface mounted IGBT switches 3 of an inverter 20 on load side. By controlling one surface mounted IGBT 11, the harmonic component currents on grid side are reduced, and the DC link voltage is controlled to reduce the rated current of the IGBT switch 3 and diode 4 of the inverter 20 on load side. The switching loss is reduced and the efficiency is increased by reducing the total number of active switches on both sides. And, the single phase - three phase power module is employed for low input voltage applications in which the IEC regulation is effective.

[00147] A single phase - three phase power module of Fig. 47 is different from the single phase - three phase power module of Fig. 20 only in that the smoothing ~~condenser~~capacitor 5 is connected from outside through junction sections (lead wires). Therefore, by controlling one surface mounted IGBT 11, the harmonic component currents on grid side are reduced, and the DC link voltage is controlled to reduce the rated current of the IGBT switch 3 and diode 4 of the inverter 20 on load side. The switching loss is reduced and the efficiency is increased by reducing the total number of active switches on both sides. And, the single phase - three phase power module is employed for low input voltage applications in which the IEC regulation is effective.

[00148] Fig. 21 illustrates a basic power conversion module for converting a three phase AC power source with a constant voltage and constant frequency into a three phase AC output power source with a variable voltage and variable frequency control system. The basic power conversion module is different from the basic power conversion module of Fig. 13 in that a pair of diodes 14 for forward connection are employed instead the diodes 12 for reverse connection, a pair of diodes 15 are provided instead the diode bridge 13, the pair of diodes 15 being serially and reversely connected between the emitter terminal, collector terminal of the IGBT switch 11, and the pair of diodes 15 being connected its connection terminal to the reactor on input side, a reactor 16 is connected in parallel to the serial circuit constituted of the surface mounted IGBT switch 11 and a pair of diodes 14 for forward

connection, and a diode 17 for reverse connection is provided which is connected between the reactor 16 and the smoothing ~~condenser~~ capacitor 5.

[00149] As is illustrated in Fig. 22, the proposed three phase - three phase system is integrated into one module using surface mounted IGBT devices and diode devices similar to the integrated IGBT standard module. The surface mounted IGBT device and diode device are designed according to the input and output requirements indicated in Table 3.

Table 3

		Load side	
		200V (motor)	400V (motor)
Power source side	200V (Japan)	Possible	Possible
	400V (Europe and others))	Possible	Possible

[00150] The proposed three phase - three phase power module can be modified by changing only the type of a surface mounted power device according to the requirement of the following specific applications.

(1) A three phase - three phase power module illustrated in Fig. 22 comprises 13 surface mounted diodes 14, 15 and 3 surface mounted IGBT switches 11 on grid side for constituting a back boost type of converter 10, and 6 surface mounted diodes 4 and 6 surface mounted IGBT switches 3 for an inverter 20 on load side. By controlling 3 IGBT switches 11, harmonic component currents on grid side are reduced, and the DC link voltage is controlled from zero volts to a voltage exceeding the maximum input voltage so as to assume the pulse amplitude modulation (PAM). By increasing the DC voltage within the high power region, the rated current of the IGBT switch 3 of the inverter on load side and the rated current of the diode 4 of the inverter on load side are reduced. A reactor 16 is connected in parallel to the serial circuit constituted of the surface mounted IGBT switch 11 and a pair of diodes 14 for forward connection, and a diode 17 is reversely connected between the reactor 16 and the smoothing ~~condenser~~ capacitor 5. Therefore, step up-down operations can be carried out. A reactor 6 is connected in the input side, and a ~~condenser~~ capacitor 7 is connected between terminals on input side.

[00151] A three phase - three phase power module of Fig. 48 is different from the three phase - three phase power module of Fig. 22 only in that the smoothing ~~condenser~~capacitor 5

and the reactor 16 are connected from outside through the junction sections (lead wires). Therefore, by controlling 3 IGBT switches 11, harmonic component currents on grid side are reduced, and the DC link voltage is controlled from zero volts to a voltage exceeding the maximum input voltage so as to assume the pulse amplitude modulation (PAM). By increasing the DC voltage within the high power region, the rated current of the IGBT switch 3 of the inverter on load side and the rated current of the diode 4 of the inverter on load side are reduced. A reactor 16 is connected in parallel to the serial circuit constituted of the surface mounted IGBT switch 11 and a pair of diodes 14 for forward connection, and a diode 17 is reversely connected between the reactor 16 and the smoothing ~~condenser~~ capacitor 5. Therefore, step up-down operations can be carried out. A reactor 6 is connected in the input side, and a ~~condenser~~ capacitor 7 is connected between terminals on input side.

(2) A three phase - three phase power module illustrated in Fig. 23 comprises 13 surface mounted diodes 14, 15 and 3 surface mounted IGBT switches 11 on grid side for constituting a back type of converter 10, and 6 surface mounted diodes 4 and 6 surface mounted IGBT switches 3 on load side. By controlling 3 IGBT switches 11, harmonic component currents on grid side are reduced, and the DC link voltage is controlled from zero volts to a voltage exceeding the maximum input voltage so as to assume the pulse amplitude modulation (PAM), and by increasing the DC voltage within the high power region, the rated current of the IGBT switch 3 of the inverter on load side and the rated current of the diode 4 of the inverter on load side are reduced. A diode 18 is connected in parallel to the serial circuit constituted of the surface mounted IGBT switch 11 and a pair of diodes 14 for forward connection, and a reactor 19 is connected between the diode 18 and the smoothing ~~condenser~~ capacitor 5. Therefore, stepping-down operation can be carried out. A reactor 6 is connected in the input side, and a ~~condenser~~ capacitor 7 is connected between terminals on input side.

[00152] A three phase - three phase power module of Fig. 49 is different from the three phase - three phase power module of Fig. 23 only in that the smoothing ~~condenser~~ capacitor 5 is connected from outside through the junction sections (lead wires). Therefore, by controlling 3 IGBT switches 11, harmonic component currents on grid side are reduced, and the DC link voltage is controlled from zero volts to a voltage exceeding the maximum input voltage so as to assume the pulse amplitude modulation (PAM). By increasing the DC voltage within the high power region, the rated current of the IGBT switch 3 of the inverter on load side and the rated current of the diode 4 of the inverter on load side are reduced. A

diode 18 is connected in parallel to the serial circuit constituted of the surface mounted IGBT switch 11 and a pair of diodes 14 for forward connection, and a reactor 19 is connected between the diode 18 and the smoothing ~~condenser~~ capacitor 5. Therefore, stepping-down operation can be carried out. A reactor 6 is connected in the input side, and a ~~condenser~~ capacitor 7 is connected between terminals on input side.

(3) A three phase - three phase power module illustrated in Fig. 24 is constituted of 6 surface mounted diodes 14 of a converter 10 on and side, and 6 surface mounted diodes 4 on load side and 6 -surface mounted IGBT switches 3 on load side. The three phase - three phase power module is employed for applications in which only efficiency is taken into consideration. A reactor 8 is connected from outside between the converter 10 on grid side and the smoothing ~~condenser~~ capacitor 5, instead providing the reactor 6 on input side of the converter 10 on grid side.

[00153] A three phase - three phase power module of Fig. 50 is different from the three phase - three phase power module of Fig. 24 only in that the smoothing ~~condenser~~ capacitor 5 is connected from outside through the junction sections (lead wires). Therefore, the three phase - three phase power module is employed for applications in which only efficiency is taken into consideration. A reactor 8 is connected from outside between the converter 10 on grid side and the smoothing ~~condenser~~ capacitor 5, instead providing the reactor 6 on input side of the converter 10 on grid side.

(4) A three phase - three phase power module illustrated in Fig. 25 is an extended version of the circuit of Fig. 23. Specifically, a reactor 18 and a smoothing ~~condenser~~ capacitor 5 are omitted. It is employed for fully removing a reactor and a ~~condenser~~ capacitor from the circuit topology. The three phase - three phase power module is proposed for applications in which IEC regulation is effective.

[00154] The proposed three phase - three phase power module can be modified to a single phase - three phase power module by changing only the type of a surface mounted power device according to the requirement of the following specific applications.

(1) A single phase - three phase power module of Fig. 26 comprises 8 surface mounted diodes 14, 15 and 2 surface mounted IGBT switches 11 on grid side for constituting a back boost type of converter 10, and 6 surface mounted diodes 4 and 6 surface mounted IGBT switches 3 for an inverter 20 on load side. By controlling 2 IGBT switches 11, harmonic component currents on grid side are reduced, and the DC link voltage is controlled for

reducing the rated current of the IGBT and the diode of the inverter on load side for applications in which IEC regulation is effective. A reactor 16 is connected in parallel to the serial circuit constituted of the surface mounted IGBT switch 11 and a pair of diodes 14 for forward connection, and a diode 17 is reversely connected between the reactor 16 and the smoothing ~~condenser~~ capacitor 5. Therefore, step up-down operations can be carried out. A reactor 6 is connected in the input side, and a ~~condenser~~ capacitor 7 is connected between terminals on input side.

[00155] A single phase - three phase power module of Fig. 51 is different from the single phase - three phase power module of Fig. 26 only in that the smoothing ~~condenser~~ capacitor 5 and the reactor 16 are connected from outside through the junction sections (lead wires). Therefore, by controlling 2 IGBT switches 11, harmonic component currents on grid side are reduced, and the DC link voltage is controlled for reducing the rated current of the IGBT and the diode of the inverter on load side for applications in which IEC regulation is effective. A reactor 16 is connected in parallel to the serial circuit constituted of the surface mounted IGBT switch 11 and a pair of diodes 14 for forward connection, and a diode 17 is reversely connected between the reactor 16 and the smoothing ~~condenser~~ capacitor 5. Therefore, step up-down operations can be carried out. A reactor 6 is connected in the input side, and a ~~condenser~~ capacitor 7 is connected between terminals on input side.

(2) A single phase - three phase power module of Fig. 27 comprises 8 surface mounted diodes 14, 15 and 2 surface mounted IGBT switches 11 on grid side for constituting a back type of converter 10, and 6 surface mounted diodes 4 and 6 surface mounted IGBT switches 3 for an inverter 20 on load side. By controlling 2 IGBT switches 11, harmonic component currents on grid side are reduced, and the DC link voltage is controlled for reducing the rated current of the IGBT and the diode of the inverter on load side for applications in which IEC regulation is effective. A diode 18 is connected in parallel to the serial circuit constituted of the surface mounted IGBT switch 11 and a pair of diodes 14 for forward connection, and a reactor 19 is reversely connected between the diode 18 and the smoothing ~~condenser~~ capacitor 5. Therefore, stepping-down operation can be carried out. A reactor 6 is connected in the input side, and a ~~condenser~~ capacitor 7 is connected between terminals on input side.

[00156] A single phase - three phase power module of Fig. 52 is different from the single phase - three phase power module of Fig. 27 only in that the smoothing ~~condenser~~ capacitor 5 is connected from outside through the junction sections (lead wires). Therefore,

stepping-down operation can be carried out. A reactor 6 is connected in the input side, and a ~~condenser~~ capacitor 7 is connected between terminals on input side.

(3) A single phase - three phase power module of Fig. 28 comprises 6 surface mounted diodes 14, 15 and one surface mounted IGBT switch 11 on grid side for constituting a back boost type of converter 10, and 6 surface mounted diodes 4 and 6 surface mounted IGBT switches 3 for an inverter 20 on load side. By controlling one IGBT switch 11, harmonic component currents on grid side are reduced, and the DC link voltage is controlled for reducing the rated current of the IGBT and the diode of the inverter on load side for applications in which IEC regulation is effective. A reactor 16 is connected in parallel to the serial circuit constituted of the surface mounted IGBT switch 11 and a pair of diodes 14 for forward connection, and a diode 17 is reversely connected between the reactor 16 and the smoothing ~~condenser~~ capacitor 5. Therefore, step up-down operations can be carried out. A reactor 6 is connected in the input side, and a ~~condenser~~ capacitor 7 is connected between terminals on input side. A single phase - three phase power module of Fig. 53 is different from the single phase - three phase power module of Fig. 28 only in that the smoothing ~~condenser~~ capacitor 5 and the reactor 16 are connected from outside through the junction sections (lead wires). Therefore, step up-down operations can be carried out. A reactor 6 is connected in the input side, and a ~~condenser~~ capacitor 7 is connected between terminals on input side.

(4) A single phase - three phase power module of Fig. 29 comprises 6 surface mounted diodes 14, 15 and one surface mounted IGBT switch 11 on grid side for constituting a back type of converter 10, and 6 surface mounted diodes 4 and 6 surface mounted IGBT switches 3 for an inverter 20 on load side. By controlling one IGBT switch 11, harmonic component currents on grid side are reduced, and the DC link voltage is controlled for reducing the rated current of the IGBT and the diode of the inverter on load side for applications in which IEC regulation is effective. A diode 18 is connected in parallel to the serial circuit constituted of the surface mounted IGBT switch 11 and a pair of diodes 14 for forward connection, and a reactor 19 is reversely connected between the diode 18 and the smoothing ~~condenser~~ capacitor 5. Therefore, stepping-down operation can be carried out. A reactor 6 is connected in the input side, and a ~~condenser~~ capacitor 7 is connected between terminals on input side.

[00157] A single phase - three phase power module of Fig. 54 is different from the single phase - three phase power module of Fig. 29 only in that the smoothing ~~condenser~~ capacitor

5 is connected from outside through the junction sections (lead wires). Therefore, stepping-down operation can be carried out. A reactor 6 is connected in the input side, and a ~~condenser~~ capacitor 7 is connected between terminals on input side.

(5) A single phase - three phase power module illustrated in Fig. 30 is an extended version of the circuit of Fig. 27. Specifically, a smoothing ~~condenser~~ capacitor 5 and a reactor 19 are omitted. It is employed for fully removing a reactor and a ~~condenser~~ capacitor from the circuit topology for applications in which IEC regulation is effective.

(6) A single phase - three phase power module illustrated in Fig. 31 comprises 4 surface mounted diodes 14 for a converter 10 on grid side, and 6 surface mounted diodes 4 and 6 surface mounted IGBT switches 3 for an inverter 20 on load side. The single phase - three phase power module is employed for applications in which only efficiency is taken into consideration. A reactor 8 is connected from outside between the converter 10 on grid side and the smoothing ~~condenser~~capacitor 5, instead providing the reactor 6 in input side of the converter 10 on grid side.

[00158] The control of the converter and the control of the inverter in each of the above power modules are known from the past, therefore detailed description is omitted.

[00159] The first aspect has characteristic effect such that various power modules such as a power module for multiple phase - multiple phase conversion, a power module for single phase - multiple phase conversion, and the like, can easily be realized. The second aspect has characteristic effect such that various power modules such as a power module for three phase - three phase conversion, a power module for single phase - three phase conversion, and the like, can easily be realized.

[00160] The third aspect has characteristic effect such that various power modules such as a power module for three phase - three phase conversion, a power module for single phase - three phase conversion, and the like, can easily be realized.

[00161] The fourth aspect has characteristic effect such that various power module can also and easily be realized which can satisfy the IEC regulation for harmonic current emissions.

[00162] The fifth aspect has characteristic effect such that various power module can also and easily be realized which can satisfy the IEC regulation for harmonic current emissions.

[00163] The sixth aspect has characteristic effect such that various power modules such as a power module for three phase - three phase conversion, a power module for single phase -

three phase conversion, and the like, can easily be realized.

[00164] The seventh aspect has characteristic effect such that various power module can also and easily be realized which can satisfy the IEC regulation for harmonic current emissions.

[00165] The eighth aspect has characteristic effect such that various power module can also and easily be realized which can satisfy the IEC regulation for harmonic current emissions.

[00166] The ninth aspect has characteristic effect such that various power modules such as a power module for three phase - three phase conversion, a power module for single phase - three phase conversion, and the like, can easily be realized.

[00167] The tenth aspect has characteristic effect such that harmonic components of power source are reduced by the reactor. Also, effects similar to those of the third aspect or sixth aspect can be realized.

[00168] The eleventh aspect has characteristic effect such that harmonic components of power source are reduced by the reactor. Also, effects similar to those of the ninth aspect can be realized.

[00169] The twelfth aspect has characteristic effect such that step up-down in voltage can be realized. Also, effects similar to those of the eighth aspect can be realized.

[00170] The thirteenth aspect has characteristic effect such that stepping-down in voltage can be realized. Also, effects similar to those of the eighth aspect can be realized.

[00171] The fourteenth aspect has characteristic effect such that various power modules such as a power module for multiple phase - multiple phase conversion, a power module for single phase - multiple phase conversion, and the like, can easily be realized.

[00172] The fifteenth aspect has characteristic effect such that various power modules such as a power module for three phase - three phase conversion, a power module for single phase - three phase conversion, and the like, can easily be realized.

[00173] The sixteenth aspect has characteristic effect such that various power modules such as a power module for three phase - three phase conversion, a power module for single phase - three phase conversion, and the like, can easily be realized.

[00174] The seventeenth aspect has characteristic effect such that various power modules such as a power module for three phase = three phase conversion, a power module for single phase - three phase conversion, and the like, can easily be realized.

[00175] The eighteenth aspect has characteristic effect such that various power module can also and easily be realized which can satisfy the IEC regulation for harmonic current emissions. Also, effects similar to those of the sixteenth aspect can be realized.

[00176] The nineteenth aspect has characteristic effect such that various power module can also and easily be realized which can satisfy the IEC regulation for harmonic current emissions. Also, effects similar to those of the sixteenth aspect can be realized.

[00177] The twentieth aspect has characteristic effect such that various power modules such as a power module for three phase - three phase conversion, a power module for single phase - three phase conversion, and the like, can easily be realized.

[00178] The 21st aspect has characteristic effect such that various power module can also and easily be realized which can satisfy the IEC regulation for harmonic current emissions. Also, effects similar to those of the sixteenth aspect can be realized.

[00179] The 22nd aspect has characteristic effect such that various power module can also and easily be realized which can satisfy the IEC regulation for harmonic current emissions. Also, effects similar to those of the sixteenth aspect can be realized.

[00180] The 23rd aspect has characteristic effect such that various power modules such as a power module for three phase - three phase conversion, a power module for single phase - three phase conversion, and the like, can easily be realized.

[00181] The 24th and 25th aspects have characteristic effect such that harmonic components of power source are reduced by the reactor. Also, effects similar to those of the seventeenth aspect or twentieth aspect can be realized.

[00182] The 26th aspect has characteristic effect such that harmonic components of power source are reduced by the reactor. Also, effects similar to those of the 23rd aspect can be realized.

[00183] The 27th aspect has characteristic effect such that step up-down in voltage can be realized. Also, effects similar to those of the 22nd aspect can be realized.

[00184] The 28th aspect has characteristic effect such that stepping-down in voltage can be realized. Also, effects similar to those of the 22nd aspect can be realized.